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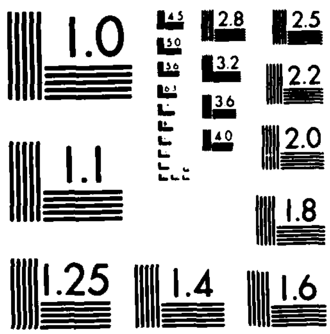

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AFFF Testing of U.S. Air Force Penetrator Nozzle

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The Skin Penetrator/Agent Application Tool (SPAAT), a new firefighting tool developed for the U.S. Air Force, was tested to determine performance characteristics when using Aqueous Film-Forming Foam (AFFF). The results showed that increasing the nozzle pressure to 150 psi from the more common fireground pressures of 50 or 100 psi provided a significant increase in stream reach, which improved fire-extinguishing capability. However, the resulting foam quality was diminished, but could be improved by aeration, although at some loss in stream reach.

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PREFACE

This report was prepared by Hughes Associates, Inc., 2730 University Blvd. West, Wheaton, Maryland 20902, under Contract Number N00014-84-C-2200 for the Naval Research Laboratory, Washington, D.C. 20375. This work was sponsored by the Naval Air Systems Command (NAVAIR) and the U.S. Air Force Engineering and Services Center, Engineering and Services Laboratory (AFESC/RD). Mr Joseph Walker (AFESC/RD), Mr James Calfee, and Ms Phyllis Campbell (NAVAIR) were the Government technical program managers. This report summarizes work accomplished between 1 May 1985 and 1 July 1985.

The nationally recognized expertise provided by Dr Homer W. Carhart and Dr Joseph T. Leonard of the Naval Research Laboratory is appreciated. Thanks are also extended to the firefighting team at the Chesapeake Beach Detachment of NRL for their assistance in performing fire tests.

This report has been reviewed by the Public Affairs Office (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nationals.

This technical report has been reviewed and is approved for publication.

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SECTION I

INTRODUCTION

A. OBJECTIVE

This test program was conducted to evaluate the performance characteristics of the newly developed aircraft skin penetrator nozzle using Aqueous Film-Forming Foam (AFFF) as the fire extinguishing agent. The test plan was designed to determine the optimum nozzle operating pressure considering its effect on the AFFF flow rate and stream reach.

B. BACKGROUND

AMETEK, under contract with the U.S. Air Force, has developed a new firefighting tool. This device, the Skin Penetrator/Agent Applicator Tool (SPAAT or penetrator), performs a dual function. It penetrates the skin of the vehicle (aircraft, railroad car, etc.) and permits extinguishing agent application without the need to withdraw the tool and insert a nozzle. Penetration is achieved with a large drill bit on the end of a rotating internal shaft, while the agent (water, Aqueous Film-Forming Foam (AFFF), halon, or PKP) flows between this shaft and a fixed, external shaft, exiting through small orifices bored in the end of the external shaft. The probability of ignition by sparking is significantly decreased by permitting the agent to flow as the vehicle skin is breached. The Air Force Engineering and Services Center, Tyndall AFB, Florida, has requested that the Naval Research Laboratory (NRL) investigate the performance of the penetrator while using AFFF.

C. SCOPE/APPROACH

The penetrator nozzle testing was conducted in three phases. First, the flow-versus-pressure and stream reach-versus-pressure characteristics were determined across the range of nozzle pressures commonly used in firefighting operations. Foam quality characteristics, expansion ratio and 25 percent drainage time were then examined at two nozzle pressures (100 and 150 psi) to determine if there are any differences in the quality of the foam generated. Finally, fire tests were conducted with the penetrator operating at two different nozzle pressures (100 and 150 psi) to determine which pressure gave the operator more ability to cut a rescue path and protect himself against a fuel surface reignition.

SECTION II

TESTING OF PENETRATOR NOZZLE

A. FLOW AND STREAM REACH TESTS

Initial testing of the penetrator involved determining the flow-versus-pressure characteristics, as well as the stream reach, at a range of pressures commonly used in firefighting operations. Nozzle pressure was determined by a pressure gauge located immediately before the agent shutoff valve on the penetrator, while the flow rate was provided by a 1-inch turbine flowmeter in a section of pipe in the supply line to the penetrator. Concrete blocks were laid out at measured intervals to assist the test personnel in determining the stream reach and width. Table 1 presents a summary of the data obtained in these tests.

B. FOAM QUALITY TESTS

Tests were also conducted to determine the foam quality, the expansion and 25 percent drainage times for the foam produced by the penetrator. These data, presented in Table 2, were collected in accordance with NFPA 11 (Reference 1) by applying foam to the standard foam collection apparatus which channels the flow into two 1000 ml graduated cylinders. The lack of a significant foam drainage time was because a large portion of the foam (in excess of 150 ml) was already in the liquid state at the time the cylinders were removed from the collection apparatus. This problem could be partially overcome by collecting the foam in a smaller graduated cylinder; however, the data obtained would not provide a valid comparison to other foam-generating nozzles.

C. FIRE TESTS

The penetrator was used to extinguish a large pool fire, 30 feet long by 15 feet wide, at nozzle pressures of 100 and 150 psi. While the penetrator is not intended as a primary extinguishing tool, the operator may have to cut his own path to an aircraft and/or protect himself from flammable liquid surface reflashes. The operator remained at one end and was permitted to move from side to side but was not allowed to proceed forward farther than the edge of the fire area. One hundred gallons of AVGAS floating on a water substrate was utilized as the test fuel. Both tests occurred when the ambient wind was 2-3 knots, blowing from right to left, from the operator's perspective. After the fire was extinguished, a small gasoline pan was placed in the pool and ignited to test burnback resistance. When 25 percent of the test area was involved with fire, agent was again applied to determine the time required to reseal the AFFF blanket. The data obtained are presented in Table 3.

TABLE 1. FLOW VS. PRESSURE AND STREAM REACH CHARACTERISTICS

Nozzle Pressure (psi)	Flow Rate (gpm)	Flow Increment (gpm/10 psi)	Stream Reach* (Length x Width, feet)
50	18.0	-	20 x 5
60	19.4	1.4	20 x 5
70	20.6	1.2	21 x 4
80	21.8	1.2	21 x 4
90	22.8	1.0	21 x 3
100	23.9	1.1	21 x 3
150	28.7	0.9	30 x 4
160	29.6	0.9	30 x 4
175	31.0	0.9	30 x 4

*The length of the stream was taken as the point farthest from the nozzle, measured along the nozzle centerline, that an appreciable amount of foam reached the ground. The penetrator was held parallel to the ground at a distance of 3 feet above the ground.

The width of the stream was measured at the point where the pattern was widest. This occurred anywhere from one half to two-thirds of the way along the stream to the point of maximum lengthwise reach. A videotape of the stream reach is available.

TABLE 2. FOAM QUALITY TESTS

Nozzle Pressure (psi)	Foam Expansion Ratio	25 Percent Drainage Time
100	3.1	Too fast to measure
150	3.1	Too fast to measure

TABLE 3. FIRE TEST RESULTS

Nozzle Pressure (psi)	Time of 95 Percent Extinguishment (sec)	Time of 100 Percent Extinguishment (sec)	25 Percent Burnback (min:sec)	Time to Re-Seal (sec)
150	30	45	1:45	20
100	35	80*	1:30	26

*Fire was 99 percent out at 45 seconds, far fringe was hard to extinguish because of reduced stream reach. The operator was required to "push" the foam along the fuel surface,rather than by direct application to the far fringe.

SECTION III

CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

Increasing the nozzle pressure to 150 psi from the more common fireground pressures of 50 or 100 psi provides a significant increase in stream reach (as shown in Table 2) as well as an increase in the total flow rate. Table 1 also shows that the increase in flow rate due to a given pressure increase (10 psi in this case) falls off at higher pressures. Table 3 shows that increasing the nozzle pressure to 150 psi improves firefighting performance. Increasing the pressure did not provide any increase in the foam quality (see Table 2). The nozzle operator did not experience any significant increase in operational problems with regard to nozzle reaction force due to the low flow rates involved.

It is impossible to comment on the suitability of the stream pattern, with the exception of effective reach, without first having postulated the "standard" fire scenarios which will be encountered. Once such scenarios are constructed, the advisability of widening the stream pattern, or perhaps moving to something akin to a fire department "cellar nozzle," can be addressed. The operator did feel that the pattern width provided radiant heat shielding for the penetrator operator.

B. RECOMMENDATIONS

It is recommended that Air Force personnel be instructed/trained to maintain a 150 psi nozzle pressure when utilizing AFFF in the penetrator nozzle. This pressure provides improved firefighting capability, compared to 100 psi nozzle pressure because of the increased stream reach.

The quality of the foam produced poses a legitimate concern. As the operator almost certainly would have to change position a number of times to extinguish a fire in a large vehicle, burnback resistance of the foam produced could be an important factor. The nonexistent drainage time indicates a very low burnback resistance and this is confirmed by the nonstandard burnback evaluation in the fire tests conducted. Increased burnback resistance, through increased foam aeration, would be a significant improvement if it could be accomplished without a significant reduction in the stream reach.

REFERENCES

1. Standard for Low-Expansion Foam and Combined Agent Systems, NFPA Standard Number 11, National Fire Protection Association, Quincy, Mass., 1983.

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